Bacterial Cretaceous Park: reassessing the meaning of sedimentary organic matter

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Extracting and sequencing of ancient DNA has proved to be difficult, and the interpretation of the meaning in an Earth history context remains controversial. Theoretical considerations and empirical studies suggest a maximum survival period for DNA of 50’000 to 1 million years [1]. DNA could persist for much longer if the degradation process is slowed down, in particular through high ionic strength, partial dehydration and anoxia [2]. This study illustrates a case of preservation in a sediment assigned to a Cretaceous Oceanic Anoxic Event.

The studied sample stems from Central Italy and corresponds to the *Urbino level*, more generally referred to as OAE1b. Well-preserved bacterial bodies embedded in extracellular polymeric substances (EPS) were observed by TEM in the sedimentary organic matter. This prompted an investigation at the molecular level, through sequencing of DNA assigned to 16S rRNA genes. Contamination was excluded through proper sampling procedures, and the age of the sample was verified by ^{14}C dating of the organic matter. The small amount of extractable DNA was sufficient to determine that most of the 16S rRNA genes identified stem from proteobacteria, many of them belonging to the group of denitrifyers. Intracellular inclusions that were analyzed with TEM/EDAX were identified as polyphosphate granules. The latter play important roles in phosphate storage. It is known that polyphosphate accumulation is widespread among denitrifyers [3]. Moreover, they represent a microbial response to lowered external pH values [4].

Consequently, molecular and microscopical approaches point to denitrifying bacteria and a slightly acidic environment during the deposition of this black shale. Sulfate-reduction dominated in the deeper sediment layers leading to higher alkalinity and to the formation of carbonates and pyrite. This study also shows that the sedimentary organic matter can possibly escape degradation and enhance the preservation of DNA thanks to packaging in EPS. Moreover, it extends the generally assumed period of time for the preservation of DNA in such environments.

We propose that biomass produced in a photic oxic-anoxic chemocline sedimented through an anoxic, hyperhaline deep water, which better preserved biological structures and bio-molecules.

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